UNIVERSITY OF Southampton

Microfluidic Devices for Structural Health Monitoring and Integrity

- An Investigation into Separation Enhancement Methods for Miniaturised Planar Capillary Electrophoresis Devices.

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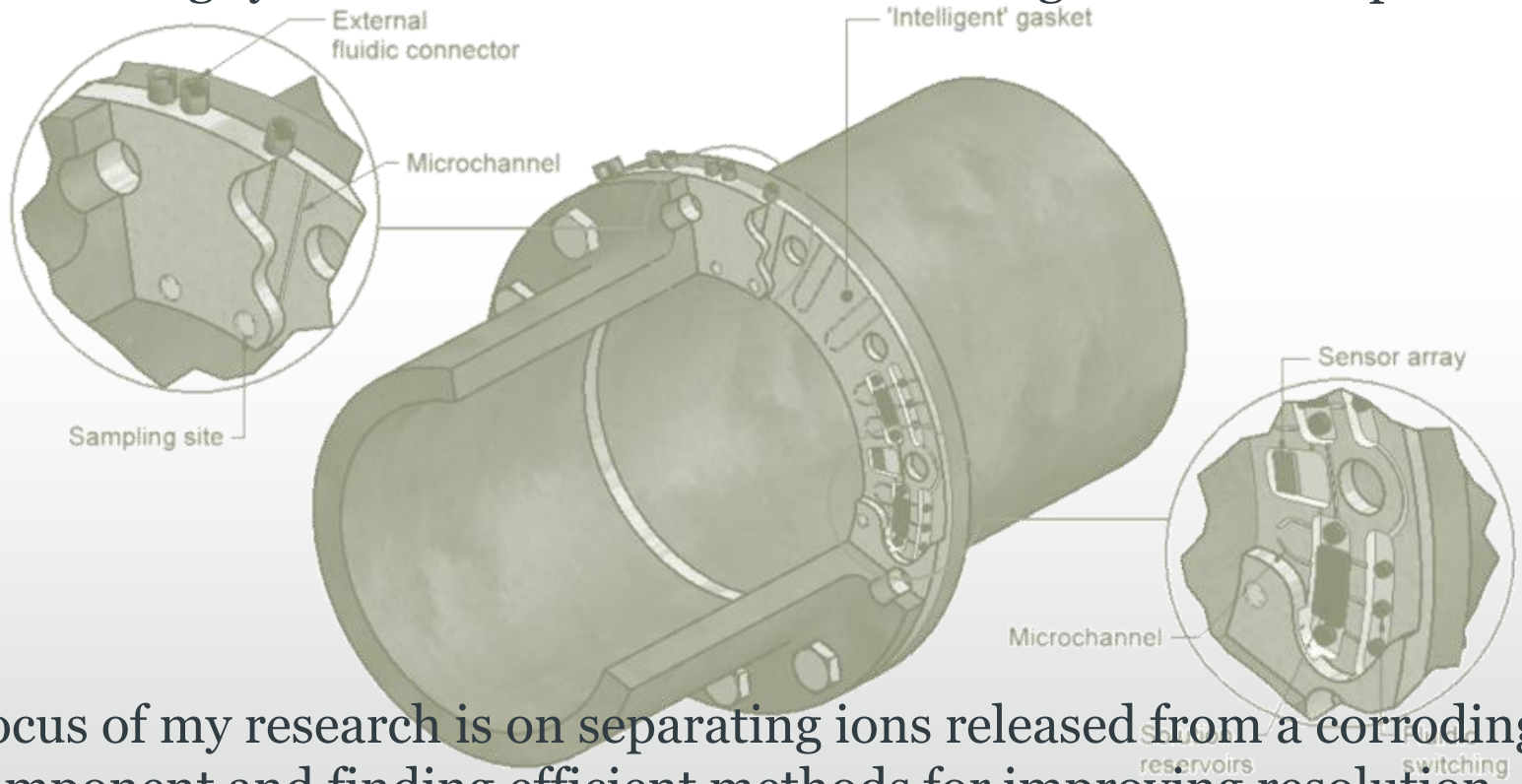
Outline

- Introduction to Project
- Overview of Capillary Electrophoresis
- Challenges of Miniaturising Capillary Electrophoresis
- Work to Date
- Methods for Enhancing Resolution
- Related Work
- Summary and Future Work

Introduction to Project

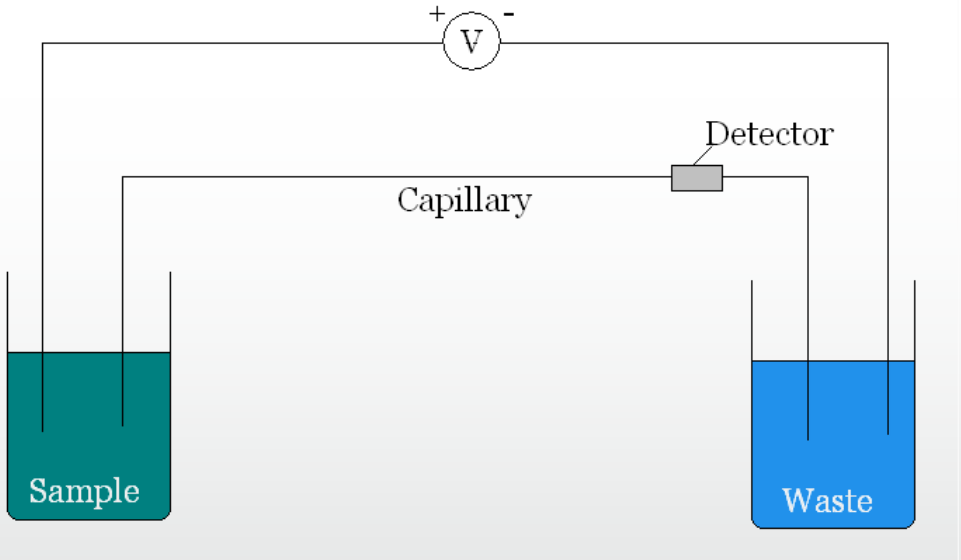
- The overall project aim is the development of a corrosion detection and monitoring system to further the understanding of corrosion processes.



- Focus of my research is on separating ions released from a corroding component and finding efficient methods for improving resolution within a miniaturised system.

Overview of Capillary Electrophoresis

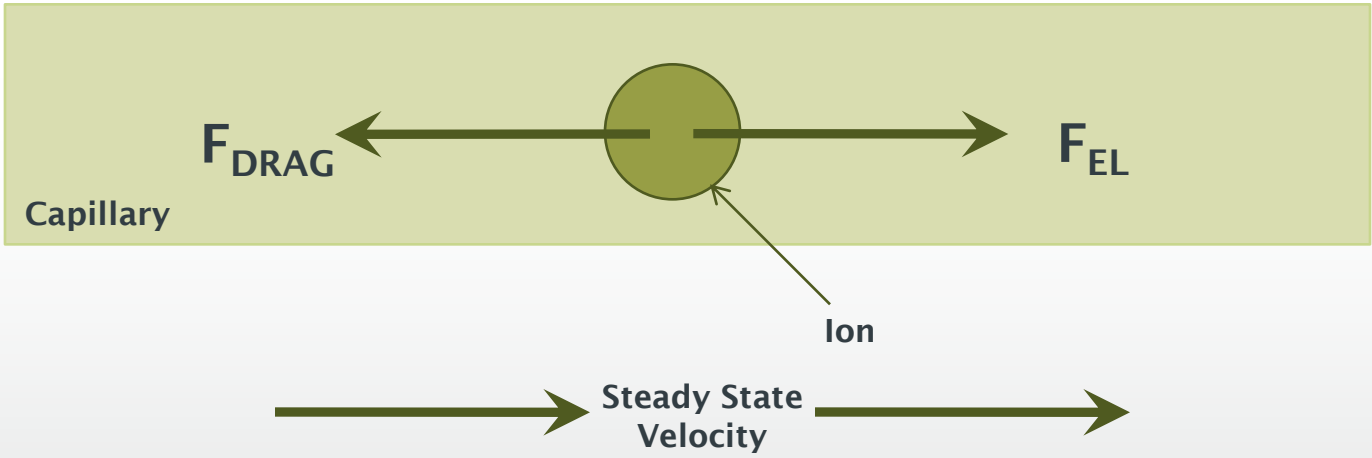
- Capillary Electrophoresis (CE) is a useful analytical tool for separating ionic species based on their electrophoretic mobility.



- The application of an electric-field drives the sample along the capillary wherein the different ionic species separate.

Overview of CE

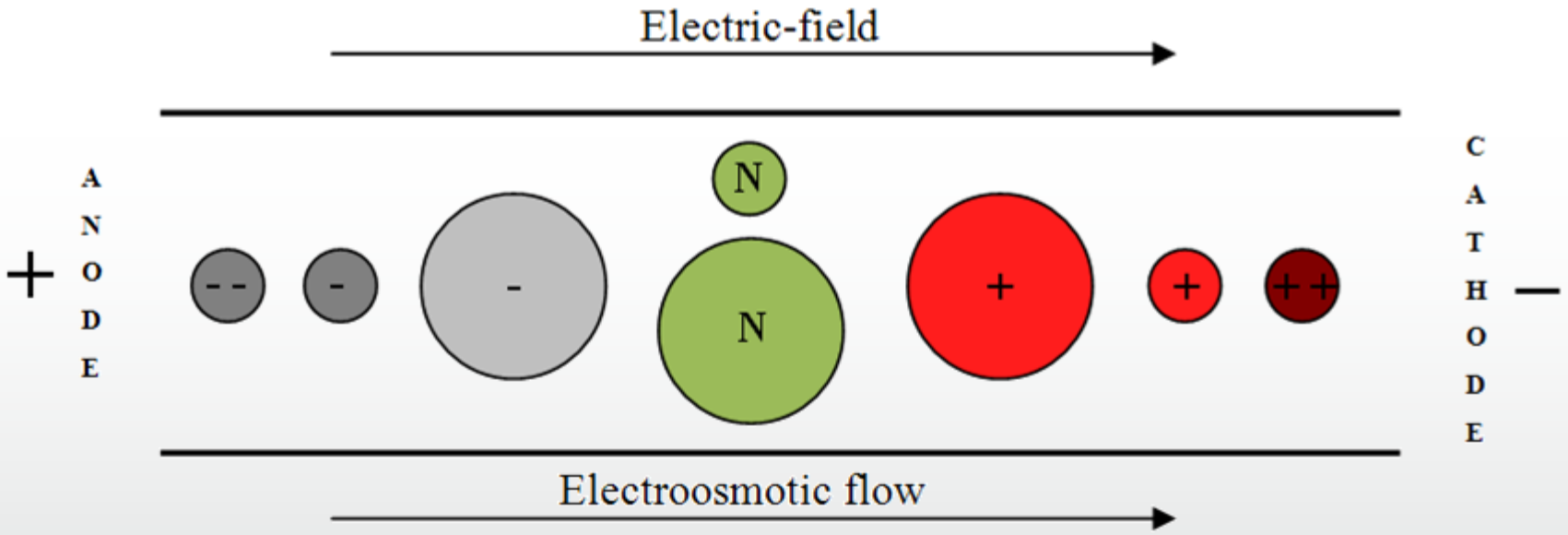
- Analytes in the capillary move at a steady state velocity when the electrophoretic force (F_{EL}) is equal and opposite to the Stoke's drag force (F_{DRAG}).



- The electric-field introduces a double layer along the capillary wall which generates Electroosmotic Flow (EOF) which contributes to the fluid flow velocity .

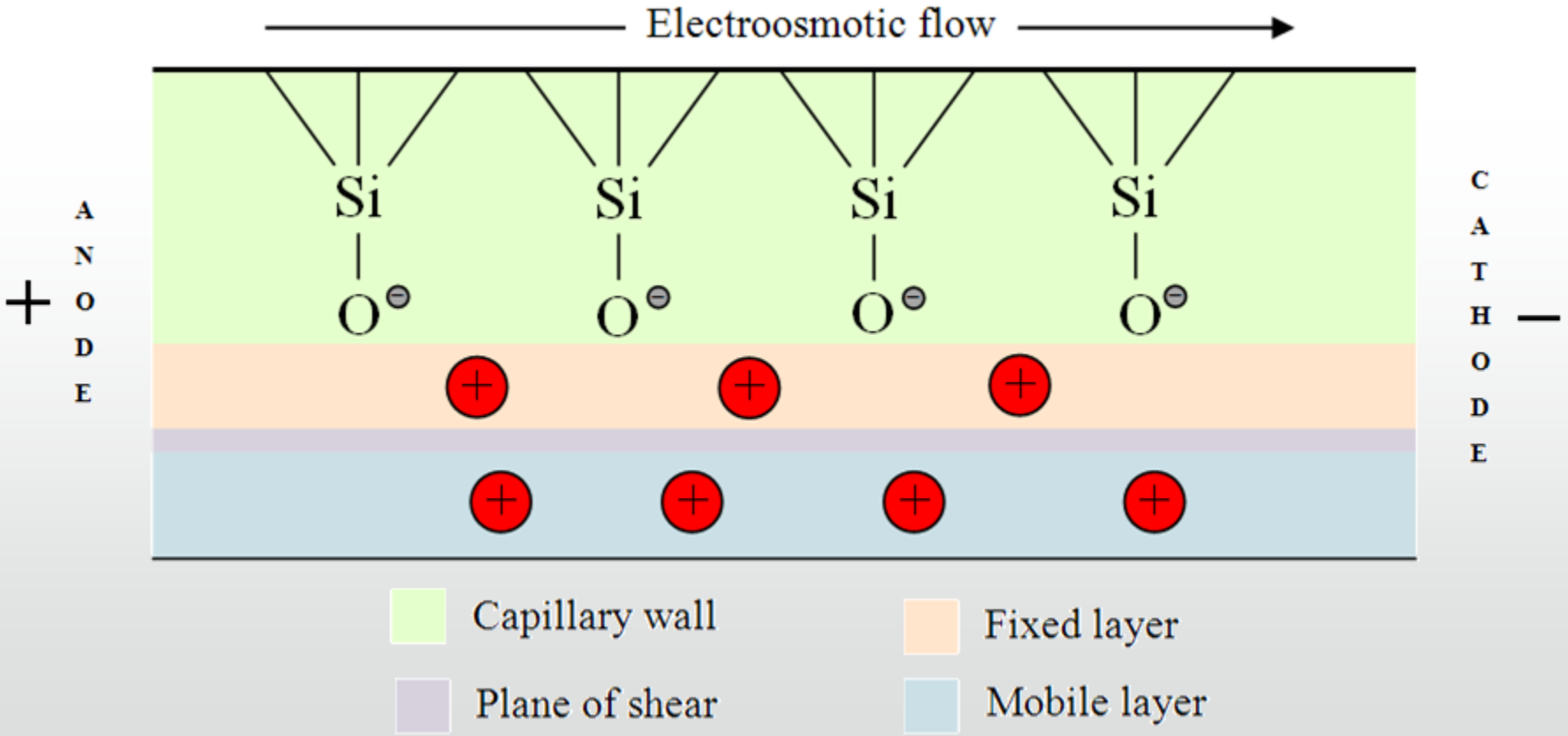
Overview of CE

- Separation of ions is based on their charge.



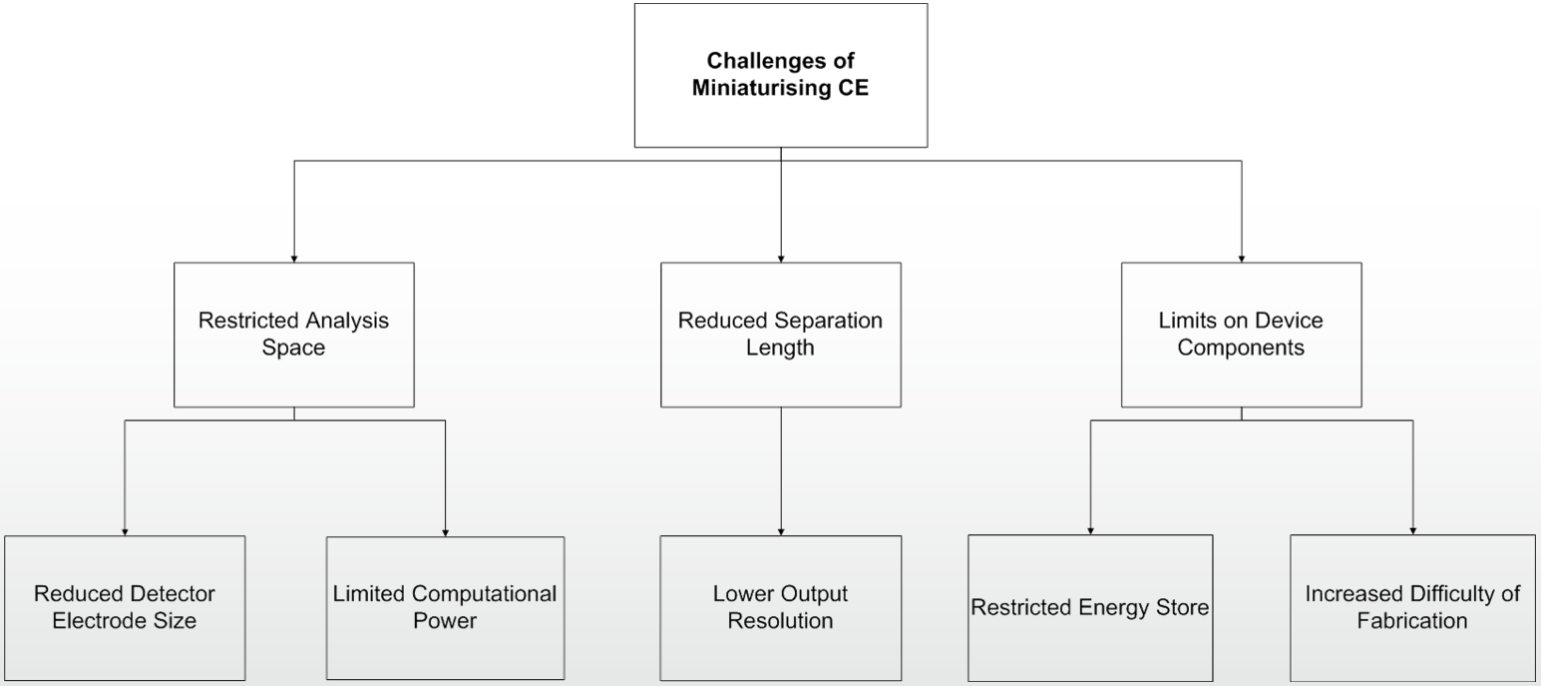
Overview of CE

- EOF occurs when electric-field is applied due to formation of a double layer



Challenges of Miniaturising CE

- Numerous challenges need to be addressed when developing a miniaturised CE device.

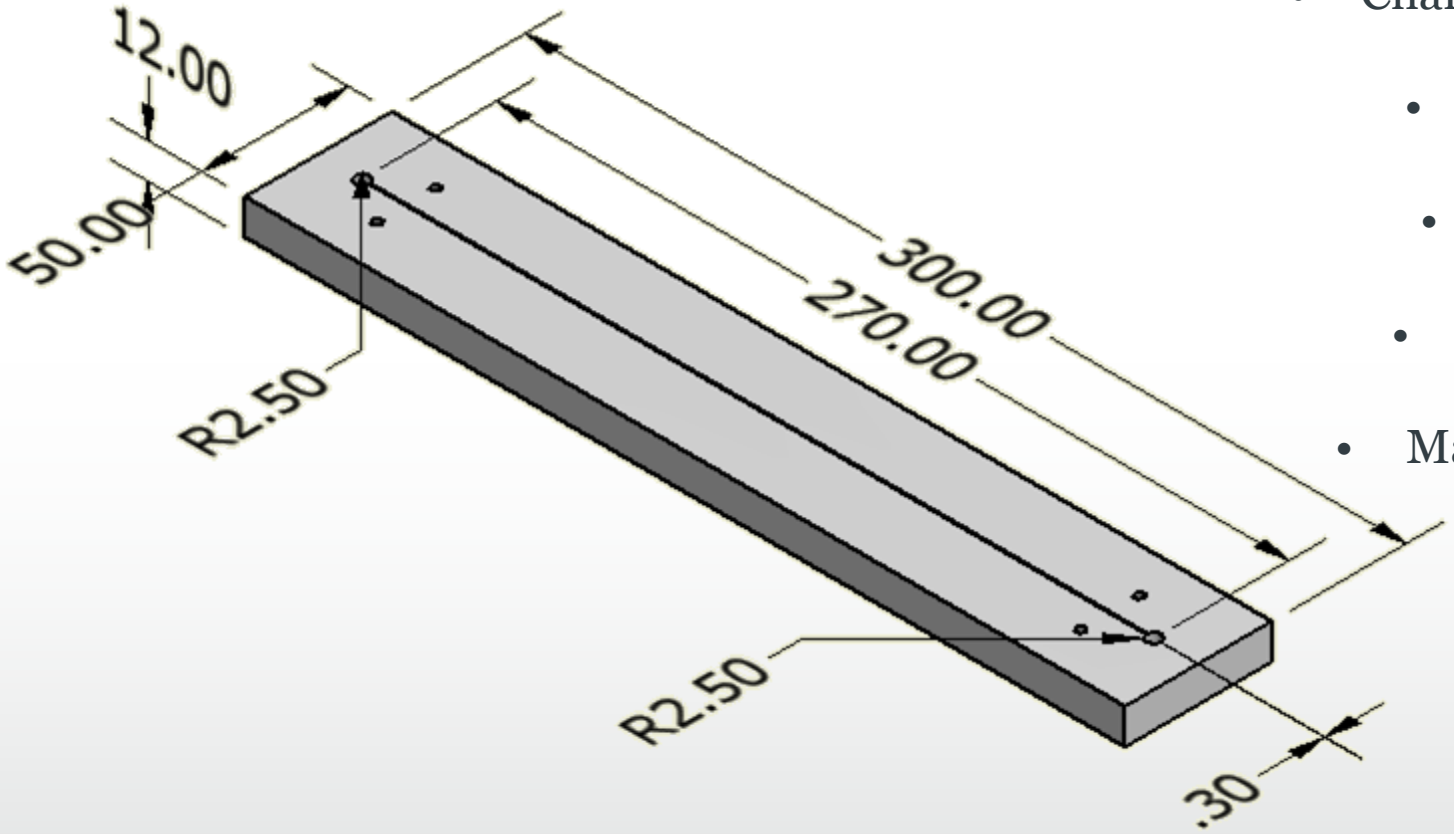


- Small capillary length reduces output resolution.
  - My primary research focus is improving the achievable separation.

Work to Date

- Survey of literature to evaluate work of other researchers in area of miniaturising CE.
- Based on other researchers' work – designed prototype miniaturised CE device in PMMA to:
  - test basic concepts,
  - highlight potential problems.

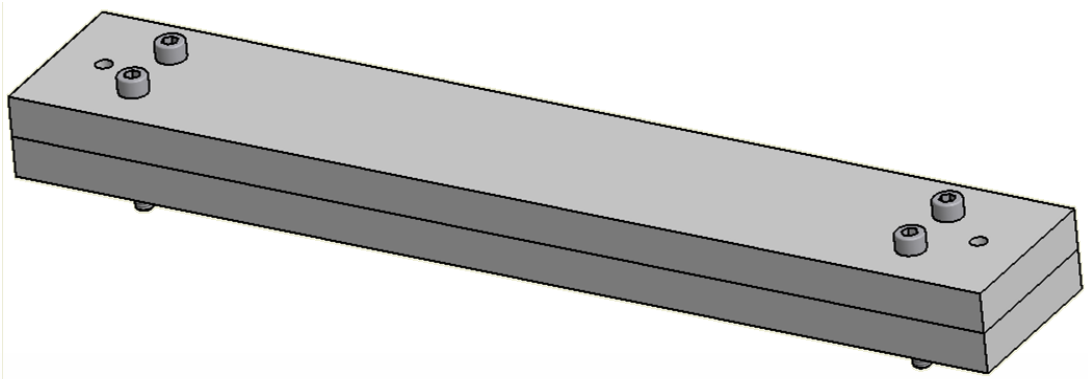
Work to Date

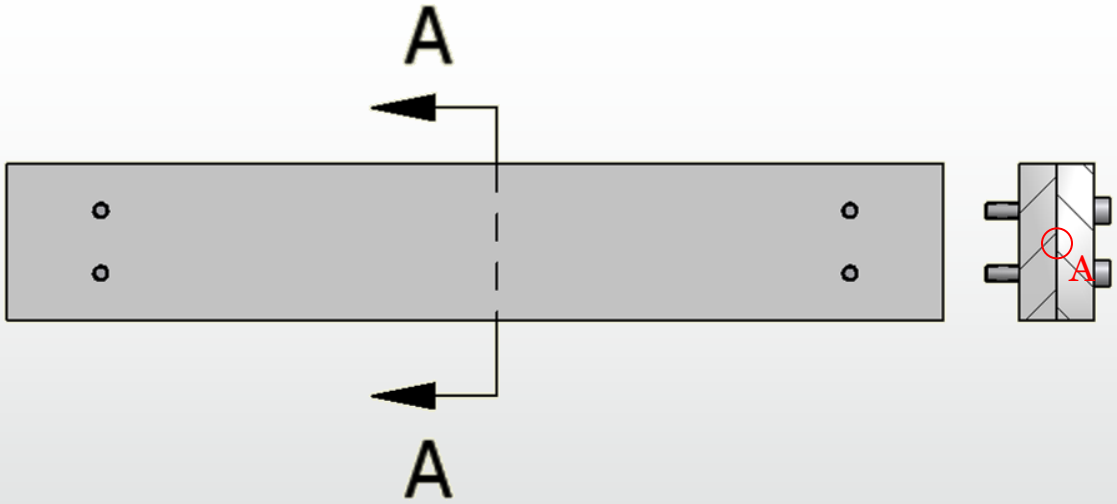


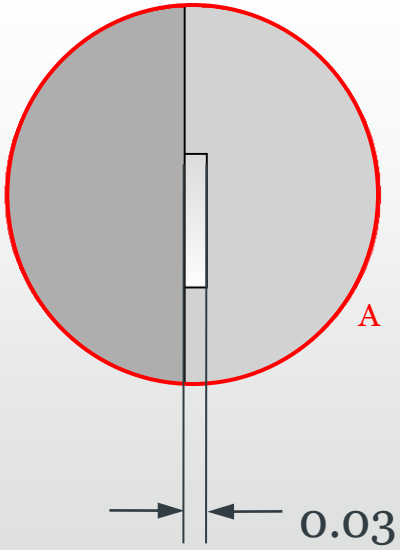
- Channel dimensions:
  - Width: 300µm
  - Depth: 30µm
  - Length: 270mm
- Material: PMMA

- This is the top layer, another layer will be placed onto this device to cover the channel.

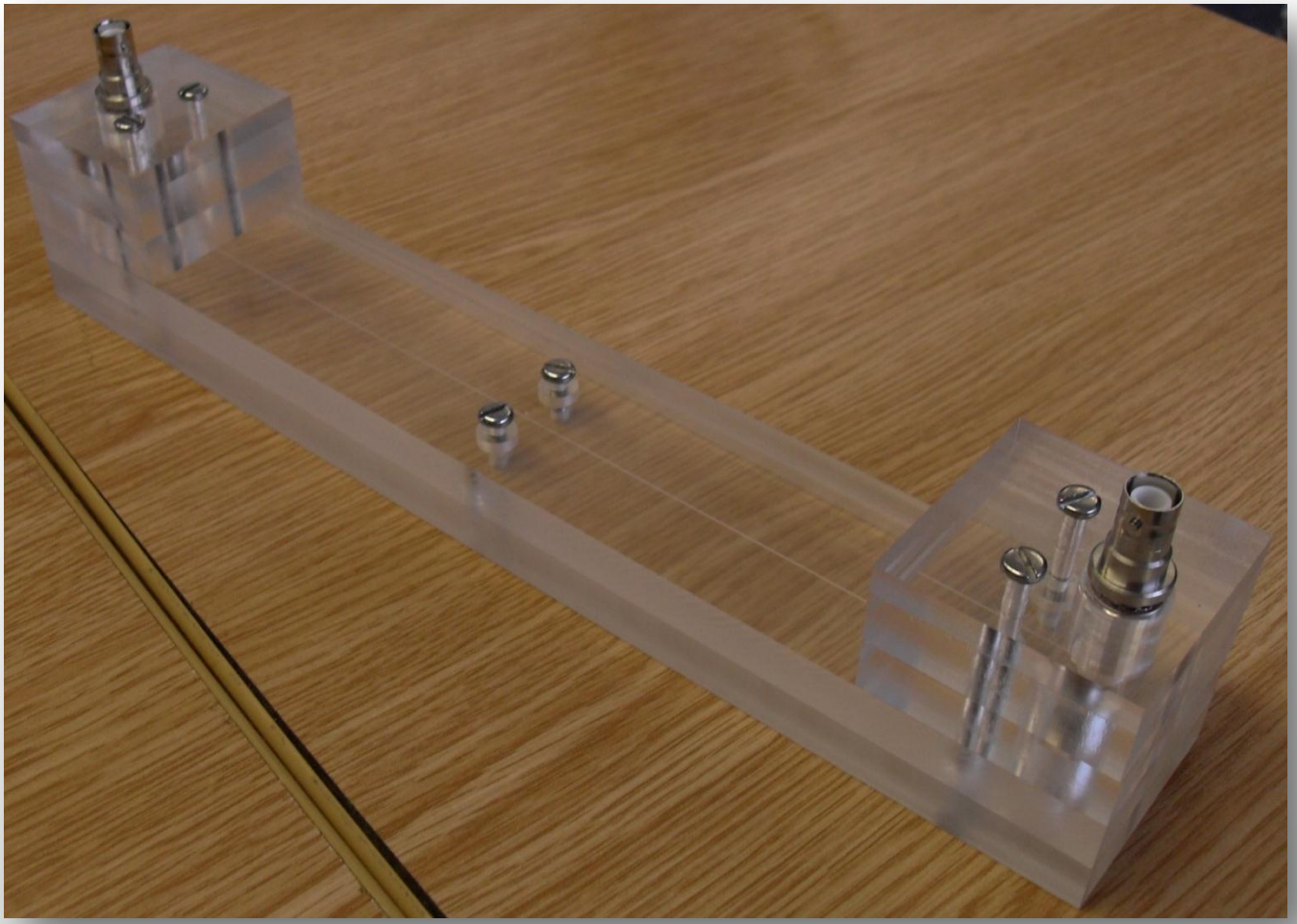
Work to Date





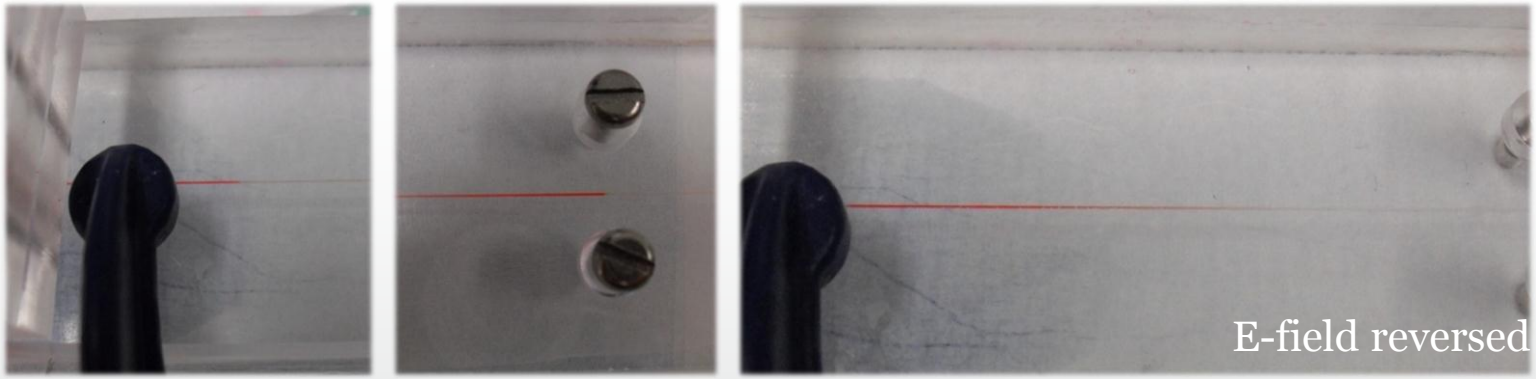


Work to Date



Work to Date

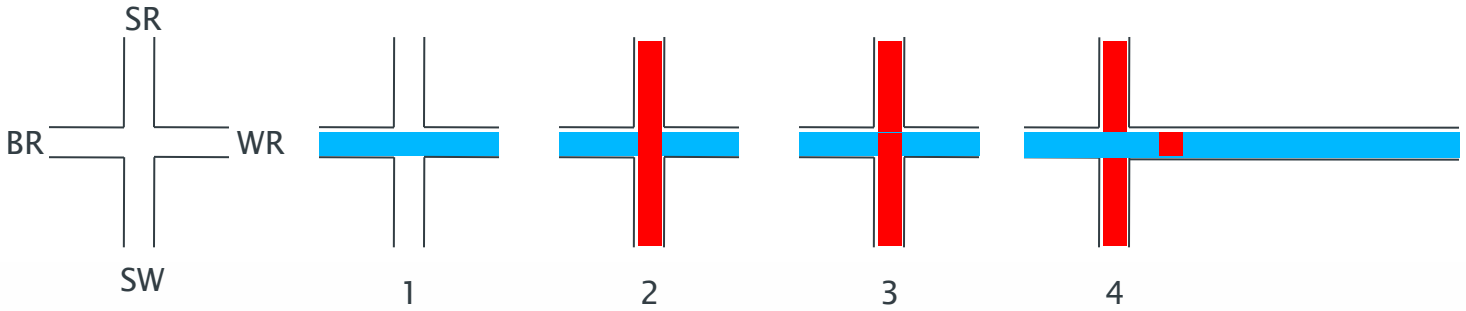
- Outcomes of experiment:
  - Switching direction of electric field in the channel
  - When the dye gets to the centre of the device (identifiable by the two screws) the electric field is reversed so that the dye is sent back to the left reservoir



  - This demonstrates control of:
    - Electric-field
    - Fluid through channel

Work to Date

- T-junction sample injection method



BR: Buffer reservoir; WR: Waste reservoir; SR: Sample reservoir; SW: Sample waste

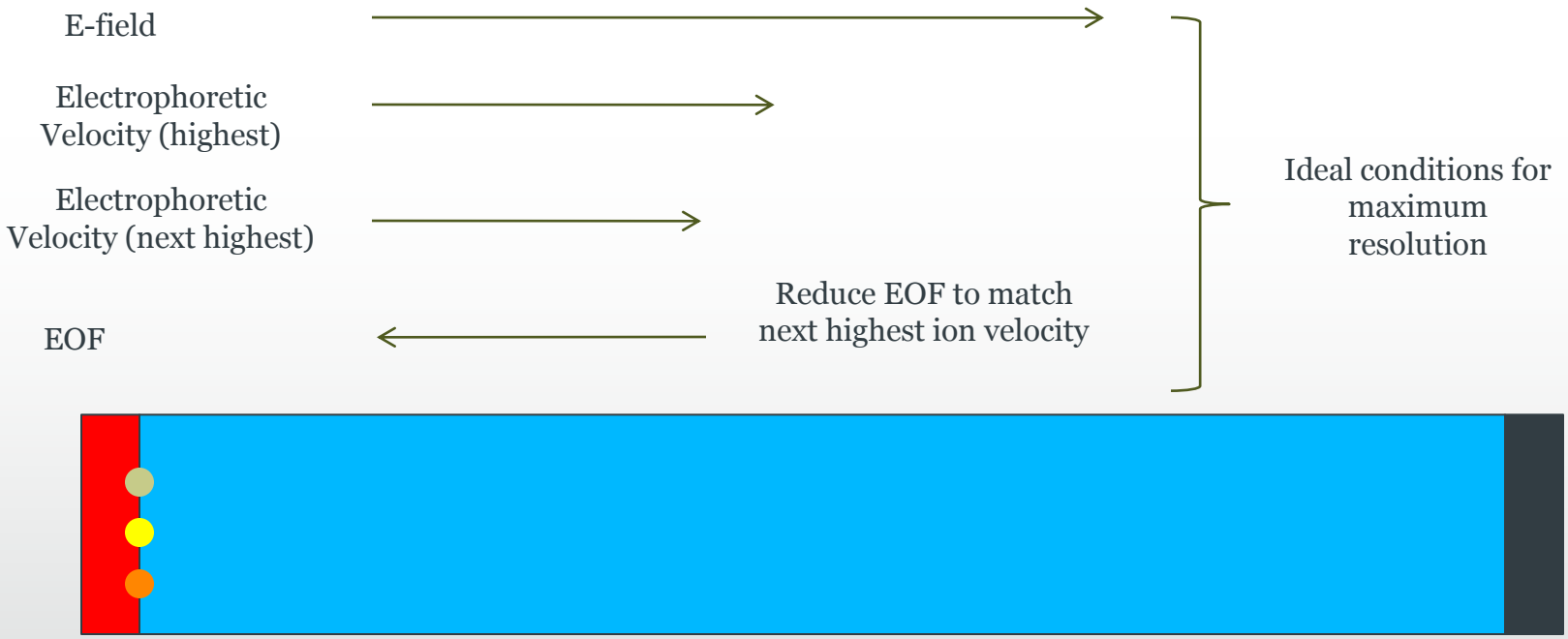
1. Fill channel with buffer solution
2. Introduce sample
3. Apply electric field
4. Electrophoretic separation

– This will allow small sample volumes to be introduced

– Enable better separation

Methods for Enhancing Resolution

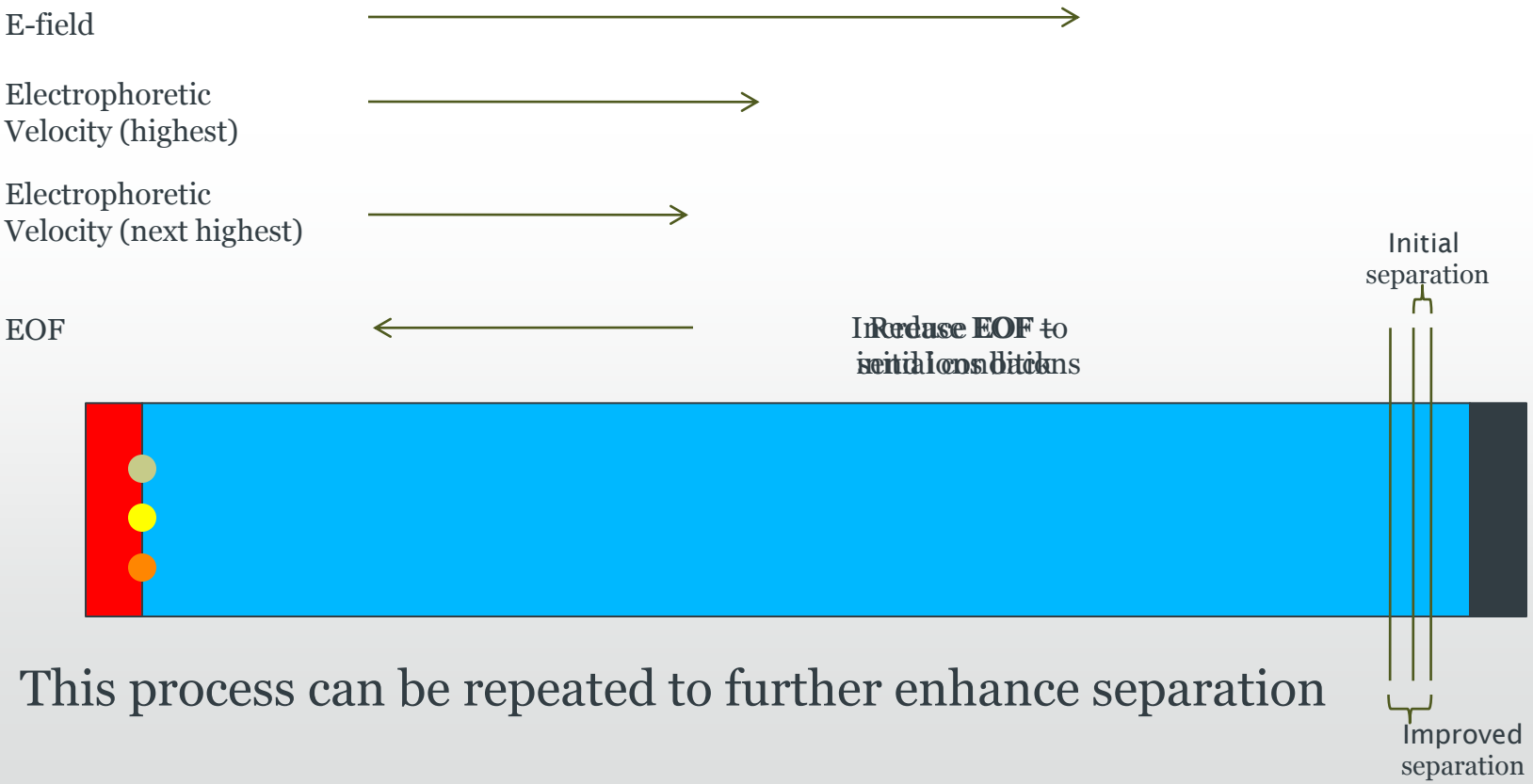
- EOF is dependent on the zeta-potential which can be modified by placing electrodes near the channel surface and applying a voltage



- Once the fastest ion is separated enough, the EOF could be further modified to match the next highest ion velocity

Methods for Enhancing Resolution

- Instead of decreasing the EOF, it could be modified to send the ions back to the start, thus effectively increasing the separation channel length



- This process can be repeated to further enhance separation

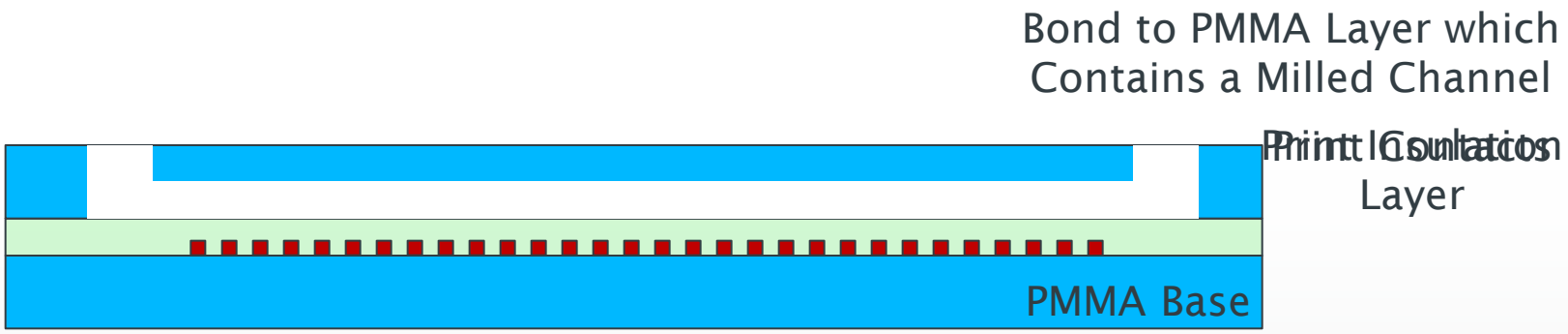
Related Work

- Searching through the literature turned up one paper where this concept had been proven on a standard CE machine:
  - C. T. Culbertson and J. W. Jorgenson – *"Increasing the Resolving Power of Capillary Electrophoresis Through Electroosmotic Flow Control Using Radial Fields"* – Journal of Microcolumn Separations 11(3) 167-174 (1999)
- This work was done on a normal CE machine not a miniaturised planar CE device.
- It appears that the incorporation of the switching method in microfluidic devices has not yet been explored.
  - There has been work which enables modification of EOF on planar devices, but this work has been used for the control of flow on microfluidic devices

Summary and Future Work

- Described CE and some of the identified potential challenges regarding miniaturising the process.
- Introduced two concepts to help resolve the issue of shorter capillaries.
- Need to fabricate device to test concepts,
  - Currently looking into screen printing the electrodes to get them closely aligned to the channel.

Summary and Future Work



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Thank you for your attention

- Questions?

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